

Assessing and Mapping Shallow Water Seabed Suitability for Artificial Reef Deployment: A Case Study in Palk Bay, Rameswaram, Ramanathapuram District, Tamilnadu, India.

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Abstract

PLANT is a national-level voluntary organization dedicated to biodiversity conservation and the sustainable livelihood development of marginalized communities in India. PLANT core focus areas include biodiversity conservation, sustainable natural resource management, innovation, advocacy for marginalized communities, and research and policy advocacy. The first Author is a founder director of PLANT Trust.

PLANT has partnered with the UNDP GEF SGP program for nearly two decades, promoting the conservation of coastal biodiversity and the sustainable use of marine resources to support the livelihood development of fishing communities. During the UNDP GEF SGP OP5 project, PLANT deployed 300 artificial reefs in two fishing villages: Chennai Fishing Harbor and C-Pudupet in Cuddalore district. The success of this project has been widely demonstrated to multiple stakeholders, encouraging the replication of the artificial

reef initiative in other coastal states across India.

Additionally, PLANT's with the support of Ministry of Environment and Forest and Climate Change, Government of India, Fisheries Department, UNDP, GEF, SGP has taken several efforts in advocacy and presentations to relevant stakeholder departments through publications and national and international events have influenced policymakers. This has led to the inclusion of artificial reefs in the fisheries policy, with

a dedicated budget allocated under the Prime Minister's scheme to implement reef projects in all coastal states of India. In addition the coastal industries also included the reef project in their corporate social responsibility budget to implement in their nearshore sea water to enhance the fisheries resource and conserve the coastal biodiversity.

Currently, with the support of UNDP GEF SGP OP7 through TERI Delhi, PLANT is implementing a similar project. This project

involves the fabrication and deployment of artificial reefs to enhance fisheries resources and enrich coastal biodiversity in eight fishing villages off the coast of Palk Bay, Rameshwaram, in Ramanathapuram District, Tamil Nadu.

Three hundred artificial reefs have been fabricated and deployed at three different locations adjacent to the beneficiary fishing villages, namely Erakadu, Karaiyur, Kudiyiruppu, Mangadu, Olaikuda, Serankottai, Vadakadu, and Sembai in Rameshwaram island. PLANT has conducted scientific sea surveys to identify suitable sea beds for the deployment of artificial reefs. A detailed sea survey study report outlines the deployment sites and community management plan to conserve the artificial reef zones as an Indigenous Community Conservation Area (ICCA).

Keywords: Sea grass, Coral reef, Artificial reef, ICCA, biodiversity. Sea Survey, UNDP, GEF, SGP.

1. Introduction:

PLANT is a Nonprofit Volunteer organization based at Chennai, India, working for the Conservation of Biodiversity and sustainable development of marginalized communities in India for past two decades with an aim to promote the following strategies in line with sustainable development goals.

- Conservation of Biodiversity and sustainable use of biological resources
- Coastal resource enhancement by deployment of reefs – “Reef for fish forever programme”, Sea Weed Culture, Open Sea Cage Culture, Mangrove Afforestation, Conservation of Sea grass, Coral reef conservation, Beach restoration and sea turtle conservation.
- Monitoring the coastal biodiversity, Plastic Waste Management, Marine Pollution control, Environment Awareness building. Community organization, skill development, promotes Entrepreneurship Development Programme, Livelihood Development, women empowerment and child development.

- Research and Advocacy, publications, uses of technology and innovation in all our interventions,

The artificial reef project has been initiated by PLANT Trust with the funding support of Ministry of Environment and Forest & Climate Change, GoI and UNDP India in the year 2016 under GEF UNDP Small Grant Programme. This project continued in GEF UNDP Small Grant Programme OP7 and deployed 300 artificial reefs to conserve the coral ecosystem and also to improve the sustainable fishing for the livelihood development of fishermen at Rameshwaram.

The success of the program has been scaled up and replicated in more than 50 fishing villages and deployed nearly 5220 reefs at the off coast of Tamilnadu, India with the support of Corporate Social Responsibility fund, International fund under Australian Direct Aid Programme, and Government fund. The success of the project is well documented and has been widespread to multi stakeholders groups to adopt this proven technology to improve the marine eco system and conservation of coastal biodiversity as a climate action programme. PLANT is promoting coastal and marine conservation activities such as coral restoration, Mangrove Afforestation, Fisheries start up business for the livelihood development, youth skill training, research and advocacy in India.

2. UNDP GEF SGP OP7 Project:

In July 2023, PLANT was selected by the Ministry of Environment, Forest and Climate Change, UNDP, and the GEF.SGP programme to deploy 300 artificial reefs off the coast of Rameshwaram. This project, aimed at benefiting hook-and-line fishermen from eight fishing villages such as Erakadu, Karaiyur, Kudiyiruppu, Mangadu, Olaikuda, Serankottai, Vadakadu and Sembai in Rameshwaram island. The structures are fabricated and deployed at the off shore of Rameshwaram. , PLANT Trust has conducted detailed sea survey at twelve locations and finally chosen three locations at Rameshwaram coast near to the beneficiary fishing villages before the deployment of artificial reef.

3. Statement of Problem

The eight beneficiary fishing villages are small communities located in the contiguous coastal area of Palk Bay on the eastern side

of the island, with a combined population of approximately 5,000 people. The residents of these villages depend entirely on fishing and related activities for their livelihood. Women in these communities are primarily engaged in selling fish, making dried fish, collecting seaweed, and gathering ornamental shells.

The fisherfolk in these villages practice small-scale fisheries in the nearshore marine waters, within their native fishing grounds extending up to five nautical miles. Most of the fishers use only FRP (Fibre-Reinforced Plastic) boats, with an estimated 150 to 200 boats available across all beneficiary villages. Importantly, the hook-and-line fishermen use small, non-mechanized fishing vessels made from thermocol, operating within the same five nautical mile range. These fishermen, from low-income groups, face significant risks while using these small vessels for their fishing activities.

Additionally, trawlers from Pamban and other areas operate within the nearshore marine area, often encroaching on the native fishing grounds of traditional fishermen. These trawlers cause severe damage to the coastal ecosystem, including seaweed, seagrass, and coral reefs.

In this context, deploying artificial reefs can act as a protective barrier to conserve the nearshore coastal ecosystem, creating an Indigenous community conservation area. Once artificial reefs are placed in suitable sites, they will enhance coastal biodiversity and rejuvenate coral reefs, seaweed, and seagrass ecosystems. Since artificial reefs are heavy concrete structures deployed on the sea bottom, trawlers will be unable to operate in the reef zones and nearshore marine waters without risking damage to their nets.

4. Objectives

The primary objective of the grant is to fabricate and deploy 300 reefs in the near shore off Rameshwaram to enhance the marine fishery resources and to conserve the coastal biodiversity for the sustainable

fishing for the livelihood development of the fishermen. The study indicates that on how the suitable sea bed locations were identified for deployment of reefs in three clusters/zones for all these proposed villages. A detail sea survey report is incorporated in this study.

Secondary Objectives

- to fabricate and deploy 300 artificial reefs at the off coast of Erakadu, Karaiyur, Kudiyiruppu, Mangadu, Olaikuda, Serankottai, Vadakadu and Sembai at Rameshwaram, Ramnad District, Tamilnadu, India to enhance the marine fishery resources and to conserve coastal bio-diversity
- to integrate reef conservation and enhancement of fishery resources with an aim to increase the coastal ecosystem and fish production through adoption of people friendly technologies
- to Increase the biomass production and Preserve the endangered species in Reefs zone
- to create coastal conservation awareness among fisher folk at Rameshwaram island in Tamilnadu
- Create conservation awareness on responsible fishing

5. Artificial Reefs

Artificial reefs are man-made structures deployed on the sea bottom to increase the surface area available for various marine organisms and create shelter for fish and lobsters to breed and feed. These structures mimic natural reef habitats, providing additional substrate for marine life and enhancing biodiversity.

There are three primary types of artificial reef structures:

1. Ring Ornamental Fish Module
2. Ferro Concrete Triangle Reef Fish Module (Somosa Module)
3. Triangular Grouper Module

The construction features of Artificial Reefs

Artificial reefs are constructed from materials such as concrete, sand, cement, blue metal, and steel, designed to withstand marine environments and provide a stable



platform for marine life to colonize. For example, a proper or ferro-concrete artificial module provides a surface area of 6 sq.m in three dimensions. When a reef is deployed at the bottom of the sea, 1 sq.m of the reef base is placed on the seabed, while the remaining 5 sq.m is available for biomass production.

Deploying 200 artificial reef structures in one artificial reef zone creates a primary core surface area of 1000 sq.m. This area serves as an Indigenous and Community Conserved Area (ICCA), promoting basic biomass production. Additionally, the 1000 sq.m of surface area available to settlers and foulers for colonization significantly enhances the biodiversity of the region where the artificial reefs are installed.

6. Artificial Reefs Help Restore Degraded Marine Ecosystems

Artificial reefs enhance marine ecosystems by providing new habitats for marine life. Within six months of installation, biological processes begin with the formation of bacterial biofilms, followed by the settlement of algae, seaweeds, sea grass, barnacles, ascidians, sponges, hard and soft corals, gorgonids, starfish, sea urchins, sea cucumbers, bivalves, chanks, crabs, lobsters, and other crustaceans. This succession of settlers creates a rich and diverse habitat that attracts a variety of fish and other vertebrates. The artificial reef area becomes a hotspot for marine life, resembling an organic soup that continuously attracts and sustains various species.

7. Artificial Reefs Restore Natural Coral Reefs Over Time

Over time, artificial reefs can evolve to resemble natural coral reefs, especially if a natural coral reef is nearby. This reduces fishermen's dependence on natural coral reefs and provides an alternative livelihood for coastal communities. Additionally, artificial reefs support a healthy population of ornamental fish, which can be harvested for additional income. They can also become sites for ecotourism, offering further economic benefits. Moreover the native species such as Seela, Paarai, Nagarai, Vaalai, Katthalai, Panna, Vilameen, Sudai, Thontan and Thirukai Sudai and Thontan

Seela, Paarai, Nagarai, , Katthalai, Panna, Vilameen, Sudai will be enhanced massively.

8. Economic and Environmental Benefits

Artificial reefs established near fishing villages allow fishermen to travel shorter distances, saving fuel and reducing expenses. Fishing can be done more quickly, ensuring better-quality fish and higher market prices. This contributes to the sustained economic growth of coastal communities.

9. Long-Term Ecological Impact

Artificial reefs contribute to sustainable livelihoods and enrich coastal biodiversity. They act as marine protected areas, as mechanized fishing vessels cannot operate in reef zones without risking severe damage to their equipment. Beneficiaries often adopt sustainable fishing practices, such as hook-and-line fishing, ensuring a balanced harvest of fishery resources.

The deployment of artificial reefs offers numerous benefits: conservation of marine ecosystems, improved fish catch, fuel savings, year-round fish availability, better economic returns for coastal fishermen, and sustainable livelihoods. These reefs enhance coastal biodiversity and provide significant ecological and economic benefits, making them a valuable tool in marine conservation and resource management.

10. Community Involvement and participation in Artificial Reef Deployment

This project is purely community-driven, aimed at empowering the fishing community in planning and executing the project components. It involves the absorption of new fishing technologies, post-harvest processing and handling techniques, and new market avenues for value-added products to maximize economic benefits. Once deployed, the artificial reefs require minimal management as the structures are safely situated on the sea floor. However, it is important to use only hook-and-line fishing methods in the reef zones to ensure sustainable harvests. This approach can be managed effectively by fishermen who regularly go to sea, preventing over-exploitation of fishery resources. The community's involvement in the

implementation process has been crucial to achieving the project's goals. Their dedication and commitment have fostered a sense of ownership, ensuring long-term sustainability and self-management of the project.

11. Addressing External Threats

To prevent inappropriate use of crafts and gears, the beneficiary group proactively communicates with other trawl fleet operators, requesting them to avoid fishing in the reef zones. This helps conserve coastal biodiversity and supports the livelihoods of local fishermen by promoting sustainable fishing practices. The beneficiary group maintains cordial relationships with all stakeholders to protect the reef zones effectively.

12. Monitoring and Support

13. The Reef Monitoring Committee periodically monitors the reef zones and collects fish catch data to analyze the project's impact with PLANT's technical guidance. The committee regularly gathers data on fishing efforts from fishermen, comparing current catches with previous data to assess improvements in fishery resources. Other stakeholders, such as the fisheries, wildlife and forest, and coast guard departments, are informed about the project and provide support and cooperation during its execution.

14. Impact of Artificial Reef Deployment Economic and Ecological Benefits

The deployment of artificial reefs has significantly increased fishery resources over a maturation period of one year. Fishermen operating in the artificial reef zones have reported catching between 3,000 kg to 5,000 kg of fish per month. This innovative intervention supports over 5000 families in Rameshwaram in Ramanathapuram district.

The Tamil Nadu State Fishery Department has recognized the success of this initiative,

standardizing the participatory fabrication and deployment module to replicate the project in other sites. As part of a co-finance component, the Australian Consulate General in Chennai has supported the deployment of 100 additional artificial reef structures for the Kasimedu fishermen, continuing the efforts initiated under OP 5 GEF SGP project.

15. Statistical Impact

In all three artificial reef zones, fishing efforts have increased to up to 5 to 10 tons per month, translating to a monthly income of approximately Rs. 15 Lakhs for 1,200 families. On average, each family earns around Rs. 12,500 to Rs. 15,000 per month from fishing, providing a sufficient income to support their livelihoods. This solution has greatly improved the wellbeing and livelihood status of the fishing community, creating a path for sustainable fishing and livelihood development.

16. Government and Corporate Support

The success of this project has led the Tamil Nadu government to sanction additional artificial reef projects across the state. The project has also attracted corporate CSR support, promoting the implementation of artificial reefs for fishing communities. For example, the Madras Atomic Power Station of Nuclear Power Corporation India Limited has replicated the artificial reef project in 17 villages, deploying over 5,000 structures in the Mahabalipuram and Kalpakkam regions through PLANT Trust.

17. Deployment of Artificial Reef

This section focuses on the deployment process of artificial reefs, including site selection through scientific sea survey, design considerations, materials used, and monitoring protocols.

18. Sea survey

Sea Survey to Identify Suitable Locations to Deploy Artificial Reef at Rameshwaram, Ramanathapuram District, Tamilnadu, India.

The Ministry of Environment, Forest and Climate Change (MoEF&CC), in

collaboration with the United Nations Development Programme (UNDP), Global Environment Facility (GEF), and Small Grants Programme (SGP) TERI and PLANT, initiated the deployment of artificial reefs at the Rameshwaram coast. A survey was conducted to identify suitable sites for the deployment of artificial reefs. The project focuses on enhancing marine biodiversity and supporting local fisheries in the Rameshwaram area of the Ramanathapuram District in Tamilnadu. The survey, conducted on June 12, 2024, assessed three sites for their suitability based on various environmental parameters. The survey team surveyed at the nine stations with the support of the native fishermen and finally chosen three suitable sites for the deployment of the artificial reef which are mentioned below.

Scientific Interpretation

The survey involved detailed observations and measurements at three potential sites for artificial reef deployment. The key parameters studied included geographic coordinates, distance from the shore, depth, number of reefs to be deployed, and the type of sea bed.

Site 1: Mangadu, Sembai & Vadakadu

Coordinates: 9.333939°N, 79.316486°E

Distance from Shore: 2.07 km

Depth: 6 meters

Number of Reefs: 100

Sea Bed: The site features a strong sandy rocky bed with no presence of corals or sea grass. This type of substrate provides a stable foundation for artificial reef structures, promoting colonization by marine organisms.

Site 2: Olakuda, Kudiiruppu & Erakadu

Coordinates: 9.310308°N, 79.360494° E

Distance from Shore: 3.03 km

Depth: 6.6 meters

Number of Reefs: 100

Sea Bed: Similar to Site 1, this site also has a strong sandy rocky bed, devoid of corals and sea grass. The rocky substrate is beneficial for the stability and longevity of artificial reefs.

Site 3: Serankotai, Karaiyur

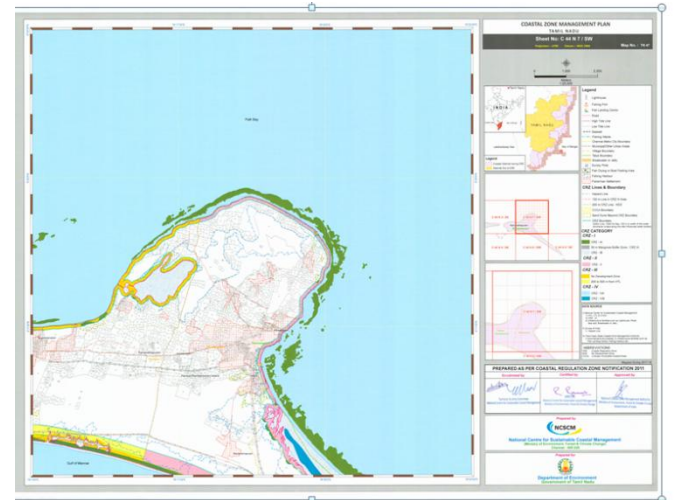
Coordinates: 9.279421°N, 79.359907° E

Distance from Shore: 5.18 km

Depth: 6.1 meters

Number of Reefs: 100

Fig 1 – Google map indicate the three different location for the deployment of Artificial Reef



Sea Bed: This site has a strong sandy bed with no corals or sea grass. The sandy substrate, while less stable than rocky beds, can still support artificial reefs, particularly with appropriate anchoring techniques.

Deployment Process

The implementing agencies adopted various mechanisms for deploying artificial reefs offshore. After selecting suitable sites, the deployment

Table I
DISTRIBUTION OF GPS COORDINATES

Sl.No	Survey Date & Time	Name of the Villages	Latitude	Longitude	Distance from Shore (KM)	Depth
1	12/06/2024 10:06 AM	Mangadu, Sembai & Vadakadu	9.333939° (9° 20' 2.18" N)	79.316486° (79° 18' 59.349" E)	2.07	6
2	12/06/2024 08:47 AM	Olakuda, Kudiiruppu & Erakadu	9.310308° (9° 18' 37.109" N)	79.360494° (79° 21' 37.778" E)	3.03	6.6
3	12/06/2024 07:47 AM	Serankotai, Karaiyur	9.279421° (9° 16' 45.916" N)	79.359907° (79° 21' 35.665" E)	5.18	6.1

locations are marked using GPS coordinates. The deployment process depends on the quantity and type of reefs to be deployed. For quantities less than 100, with lightweight reefs such as ring and ferro-concrete modules, the reefs are deployed using small traditional craft. For larger quantities, such as 200 or more structures that include all three types of modules, a marine vessel or barge is used to deploy the artificial reefs at the specified locations within a day.

Conclusion

The survey identified three suitable sites for the deployment of artificial reefs in the Rameshwaram area. All sites are characterized by strong sandy or sandy rocky sea beds, which are conducive to the establishment and stability of artificial reefs. The absence of corals and sea grass suggests that these areas are suitable for reef deployment without negatively impacting existing marine ecosystems. The deployment of artificial reefs at these sites is expected to enhance marine biodiversity, provide habitats for various marine species including sea weed, sea grass and coral reefs, and support local fisheries.

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